NAIST® Research Highlights

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Photonics

Implant sensor images brain activity in vivo

Image sensor implant makes it possible to record the neural activity of a living mouse as it moves

A fluorescence imaging system that can be implanted in the brains of living and freely moving mice allows the neural activities of mice to be monitored during different behaviours. The system, which was developed by researchers at NAIST in Japan, has the potential to provide fresh insights into how neural networks function in the brain.

The implantable fluorescence imaging system, fabricated by Jun Ohta of NAIST's Graduate School of Materials Science and his colleagues, consists of a set of blue/green light-emitting diodes (LEDs) and a tiny image sensor — a smaller and simpler version of those commonly found in digital cameras. The image chip contains 120 × 268 pixels and is just 1 millimetre wide and 3.5 millimetres long.

Light from the LEDs excites fluorescence in brain cells that have been doped with a voltage-sensitive dye. Consequently, the intensity of the excited fluorescence varies with changes in the membrane potential, which is related to neural activity. The emitted fluorescence is then captured by the image sensor and transferred via a cable to a computer and additional electronics where it is analysed. This is performed at a rate of 60 frames per second, enabling movies of neural activity to be recorded.

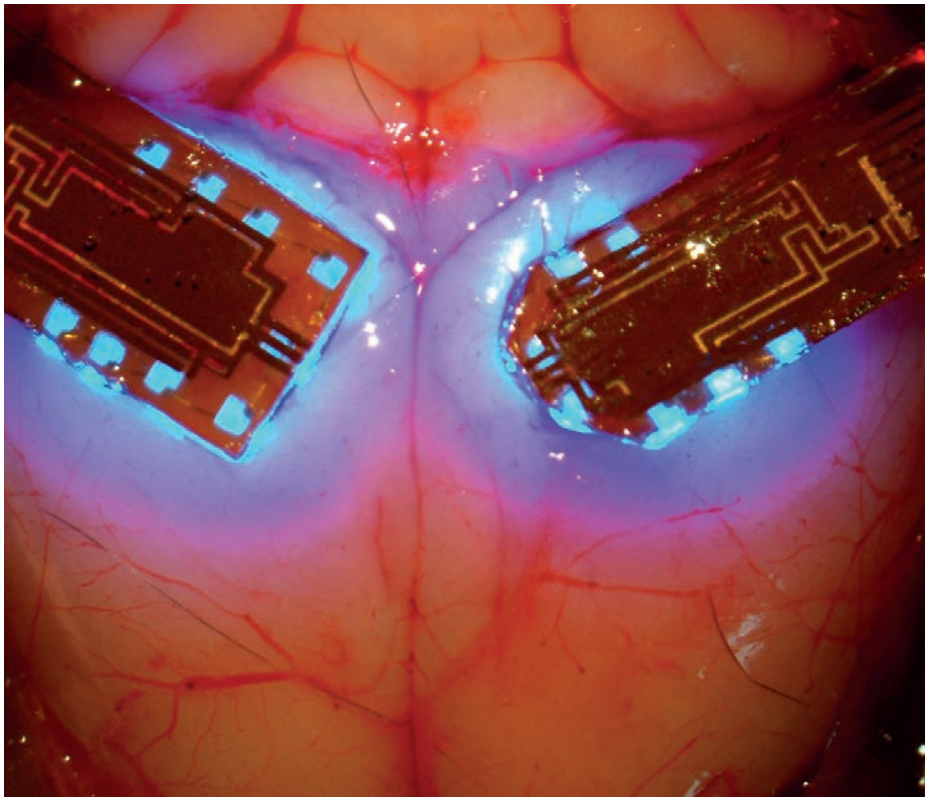
> **"In contrast, the NAIST imaging system can function even when the subject is moving."**

While techniques such as conventional fluorescence microscopy and functional magnetic resonance imaging are capable of recording activity in different parts of the brain, they require the subject to remain perfectly still. In contrast, the NAIST imaging system can function even when the subject is moving.

"The system we have developed makes it possible to take real-time images [of the brain activity] of small experimental animals such as mice and rats in a freely moving condition," explains Ohta, "which is important for studying learning and memory functions."

By installing two sensors in the left and right hemispheres of the brain, the team has mainly used the system to study activity in the visual cortex of mice. However, Ohta says the system could be used to investigate other functional areas of the brain.

The researchers have several ideas for future work. One idea is to create a wireless system; this would eliminate the need to have a cable connected to the animal, which considerably limits its movement. Another plan is to develop a microimaging device that can be implanted in the limbic system — a deep brain region associated with emotion and addiction and hence important for studying mental diseases.



Two image sensor chips implanted in the two visual cortices of the brain of a mouse.

Reference

1. Novel implantable imaging system for enabling simultaneous multiplanar and multipoint analysis for fluorescence potentiometry in the visual cortex. Kobayashi, T., Motoyama, M., Masuda, H., Ohta, Y., Haruta, M. *et al. Biosensors and Bioelectronics* **38,** 321–330 (2012).

More information about the group's research can be found at the Photonic Device Science Laboratory webpage:
http://mswebs.naist.jp/LABs/pdslab/index-e.html